outboard has made it possible to establish transportation routes in areas where waterways were the only highways. In addition to improving communications with isolated communities, the introduction of the outboard in such areas as Brunei State, Borneo, Thailand, Indonesia, The Philippines, and several others, led to the use of other mechanical equipment. In many instances the transportation of such equipment was made possible only by the use of outboard-powered craft.

The improved transportation facilities that resulted made it possible for the farmer and planter to get his products to market faster and at a lower cost, with a resulting improvement in economy.

In addition to health improvement attained through the increased production of fish and the attendant increase in the protein requirement, the outboard made improved medical care available, even in isolated areas. In the Bahamas, for example, a medical officer is now able to serve a dozen communities through the use of an outboard boat. In times of disaster, medical aid, food and relief equipment can be transported without delay, which has resulted in the preservation of life and property.

A score of examples can be pointed out, highlighting use of the outboard during times of disaster. They serve to transport relief equipment conveniently and without delay. When spring tides, swollen rivers and northwestern gales spilled flood waters over Holland's dikes last year, creating one of the most disastrous inundations in the country's history, the Dutch Red Cross and the Corps of Engineers put outboards into operation in flooded area, with excellent results.

Outboards, in the service of the Royal Danish Life Saving Squad, have played a vital role negotiating treacherous waters. The British Navy's salvage squads frequently depend on outboards. When flood waters of the Kariba Dam in South Rhodesia threatened to wipe out thousands of helpless animals, rescue teams, using outboards, transported and guided them to safety.

Outboards are used, and have been used in many areas, under many different circumstances and conditions throughout the world. No longer can the outboard motor be regarded as a recreational toy. In more than a score of countries where recreational boating is little known, the outboard has proved to be an important industrial workhorse, with a potential that even today has not been fully explored.

Effects of Pesticides on Commercial Fisheries

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THE NEED FOR AN EXTENSIVE and continuing research program to determine the effects of agricultural chemicals on our fish and wildlife resources has been apparent for many years. The ever-increasing amount and variety of these chemicals in use on farms and forests have made the problem one of national concern. More recently, the need for comprehensive studies in the estuarine environment has been recognized, and various agencies have initiated limited investigations in this area. Much of the research done in the past has demonstrated that these chemicals may be highly selective in their toxicity even to closely related forms. Although they have been developed primarily for their toxic effects on particular groups such as insects, rodents, or weeds, some have had unexpected and disastrous effects on associated biota. Their effects may vary widely in different environments depending on meteorological conditions such as wind and rain. The character of the soil, and in aquatic habitats the water chemistry and types of sediments, may greatly influence their toxicity.

Knowledge of these variables alone makes it highly desirable that thorough studies be conducted in our estuarine habitats where more than thirty of our most important commercial species of fish, shellfish and crustacea spend a part or all of their lives.

There are other and more compelling reasons why intensive investigations of this type of chemical pollution are needed to protect our fishery resources.

Despite the fact that a majority of the pesticides are only sparingly soluble, it is inevitable that sooner or later significant amounts of them will collect in our rivers and estuaries, either as particulate matter, adsorbed on silts and detritus or perhaps in some new chemical relationship.

It must be noted that many of these chemicals are in use today because of their specific toxicity to arthropods. Yet it is an arthropod, the shrimp, our most valuable commercial species, which utilizes estuaries as its nursery grounds. In this same group, of course, are both kinds of lobsters, the blue crab and the stone crab, all of considerable economic importance.

It is a matter for especial concern that marine bottom forms including clams and oysters may be unusually susceptible to these chemicals. They may be poisoned by them, or what could be more serious, they may concentrate these poisons in their digestive organs and other body tissues. Unfortunately it is just these forms which we use whole and frequently unprocessed as food. The analogy here to the situation in which birds were poisoned indirectly by eating earthworms that had concentrated pesticides in their tissues is both appropriate and threatening.

There have been accidental but dramatic instances in which extensive mortalities occurred to fish and crab populations in different areas as a result of insect control programs. Such incidents are, however, the exception and our real problem concerns the immediate and long range effects of pesticides reaching estuarine areas indirectly.

At present, we do not know how much or what pesticides are being transported from farm and forest lands through drainage basins into the estuaries. We have no dependable qualitative and quantitative tests for identifying them when highly diluted in the marine environment. We do not know if degradation products of these pesticides, formed in transit, are more or less lethal to marine fauna than the parent chemical. Nor do we have much information on the cumulative effects of sub-lethal concentrations. The possibility of synergistic effects with other environmental components is an untouched field for investigations.

The fluid medium of the estuarine environment makes it much more possible for harmful combinations or sequences of events to take place than in terrestrial applications of these chemicals. Consequently, it is difficult to predict from laboratory testing programs the end results of field applications. There are inherent difficulties in maintaining most of the commercial species of fish and shellfish for long periods under laboratory conditions.

For these reasons, much of our initial effort has been devoted to relatively rough screening programs of the most important pesticides and to the development of appropriate bio-assay techniques.

During the past fiscal year, Bureau of Commercial Fisheries laboratories have made considerable progress on the overall problem. Examination of the accumulated data has been discouraging, not because of a lack of results, but because they demonstrate the complexity of the problems with which we are faced.

Some of these results I should like to review briefly and indicate their possible implications.

The Biological Laboratory at Milford, Connecticut, because of its excellent technical facilities and experience, has concentrated its efforts on studies of phytoplankton and molluscan larvae in relation to pesticides. Their studies have shown the extraordinary toxicity of some of the herbicides to the unicellular phytoplankton utilized by molluscan larvae as food. One of these, lignasan, was highly toxic at concentrations of only a few parts per billion. The other herbicides tested were toxic at much less than one part per million and this was true for many of the insecticides as well. It is obvious what disastrous effects relatively small quantities of such chemicals could have in upsetting the food web in a restricted estuary.

Of equal concern are their findings that many of the most common insecticides have a strongly toxic effect on oyster and clam larvae. Relatively high concentrations, up to 1 ppm, were required to cause significant mortality, but at lower concentrations, growth rates were invariably decreased.

The Galveston Biological Laboratory has conducted an insecticide screening program with emphasis on commercial species of shrimp. Their data show that all of these chemicals are extremely toxic to shrimp, causing 50 per cent mortalities at concentrations of less than 50 parts per billion. Equally disturbing is their finding that the same chemical may have entirely different toxic values when formulated with different so-called inert carriers. For although there are only 200 or so basic chemicals in use today, the number of formulations runs into the thousands.

The Biological Laboratory at Gulf Breeze, because of special facilities for evaluating the activity of oysters, has concentrated its efforts on, first, a screening program to determine the toxicity to oysters of the common pesticides, and, second, to the development of better techniques of bio-assay.

In working with oysters, the concept of LD_{50}, or the concentration of a poison causing a 50 per cent mortality in a given length of time, has little meaning. If oysters don't like their environment they close their valves and effectively remove themselves. Consequently, in our testing programs it is necessary to use concentrations of the pesticide sufficiently dilute to prevent the oyster from closing.

Initially, pesticide toxicity was evaluated by determining the number of hours per day test animals were open and presumably feeding. Continuous kymograph recordings were made of their shell movements in order to measure their activity. Under these conditions, it was found that their activity might appear to be unaffected for days or even weeks at a given concentration of a chemical before adverse changes could be detected. As a double check on the value of activity data, records were maintained on weekly growth increments of young oysters kept in the same aquaria. It was soon found that not only were growth increments equally reliable, but there was no time lag in the appearance of adverse effects as shown by decreased growth rates. A logical sequence to these results was to discover how long a time interval was needed to establish changes in growth rates. Obviously, tests requiring four to six weeks for conclusive results, as in the shell activity work, are of limited value in a program faced with testing hundreds of chemicals.

We have now standardized our methods for using the growth rate of young oysters as an index of chemical pollution and they merit a brief description here. Small oysters from 1-1½ inches in length are used since they grow in all months of the year in contrast to larger oysters in our area. The posterior or open end of the valves is filed with a rasp until all of the membranous or soft new shell growth is removed. The removal of this shell does not harm the tissues of the oyster which contracts internally when it is handled. With moderate care there is no danger of actually making an opening into the shell cavity. Control and experimental groups are then placed in suitable containers of circulated untreated and treated sea water. Measurements of shell deposition are made at convenient intervals, usually daily for three days, using an ocular micrometer with low magnification. Records are maintained on the growth increments of the oysters individually.

We find that only 10 oysters are required to provide data for a statistically valid sample. Within a wide range of hydrographic conditions, control oysters will deposit approximately one mm of new shell growth per 24 hours. Since a control group is used, there is no necessity for maintaining constant salinity and temperature levels. One day's observations are normally sufficient to determine the required range of concentrations to be tested and three day tests provide definitive results.

Obviously this technique can not be applied to work with mature fish and crustacea but perhaps it is applicable to larval forms which grow fast enough so that changes in rate of growth may be quickly observed.

Both the Milford and Gulf Breeze workers have noted that the first evidence of toxicity of pesticides to shellfish is a decrease in growth rates. It is reasonable to suggest that our ability to evaluate this item may eliminate much costly and time-consuming work in the future. We are interested not only in the pollution levels causing acute toxicity and death, but also those causing more subtle reactions which over a period of time may affect reproductive potential and longevity.

Using the growth of small oysters as a criterion of pesticide toxicity, we find two points of particular interest. After the lowest concentration of a chemical that causes a decrease in growth has been determined, we find that exposure to a further ten-fold dilution produces no apparent ill effects, even over a period of several weeks. Secondly, when adversely affected oysters are returned to clean sea water, the normal growth rate is reinstated within a short period of time, usually a few days.

We may hope that so far as oysters are concerned, and perhaps other estuarine forms, that not only are subacute toxicities transitory but that they may be avoided by relatively small increases in the dilution factor. It is possible that under natural conditions, and barring accidents, average dilution factors are so great that these chemicals pose no real threat to estuarine and marine forms.

These items are not suggested to lull us into any feeling of security with regard to chemical pollution but rather to point out how a coordinated and productive research program can provide the basis for better resource management. Agricultural chemicals are here to stay. With sufficient knowledge of their immediate and residual effects, it will be possible for us to utilize them to the fullest extent and with minimum damage to our valuable natural resources both on land and in the sea.